



Deep magic



Chaz

 [**cvillette**](https://cvillette.livejournal.com/)

<https://cvillette.livejournal.com/>

2008-03-21 22:44:00

MOOD: 😊 tonight's plague: beers

MUSIC: a girl in the shower

Tonight represents a fantastic coincidence of the stars.

It may surprise you to know that I was raised Catholic (1). And grew up a mathematician, which means I'm one of ten (3) people in the continental U.S. who cares about the *computus* (4) *paschalis*. Which is to say, the method used to compute the actual date on which Easter Sunday falls.

Which is an arcane and wonderful process.

Generally speaking, we say that Easter is the first Sunday after the first full moon on or after the Vernal Equinox. However, that's an approximation, because the full moon doesn't always fall on the same day everywhere in Christendom. So the church uses an approximation, called the ecclesiastical or Paschal full moon (5).

The date of this movable feast is arrived at using a method based on the epacts (6) between the tropical (actual solar) year and the lunar year, according to the 19-year Metonic cycle (7), which is the amount of time it takes for solar and lunar years to (roughly speaking) align (8).

Are you with me so far? No? Okay. To restate in short words: the full moon from which Easter Sunday is reckoned is not an actual full moon. It is a *virtual* full moon, determined by a calculation involving the rate of drift between the solar and lunar years.

Wikipedia explains thusly:

The solar year is reckoned to always have 365 days (excluding a small remainder). A lunar year of 12 months is reckoned to have 354 days, meaning the average lunation is $29\frac{1}{2}$ days (excluding another small remainder). The solar year is 11 days longer than the lunar year. Supposing a solar and lunar year start on the same day, with a crescent new moon indicating the beginning of a new lunar month on 1 January, then the lunar year will finish first, and 11 days of the new lunar year will have already passed by the time the new solar year starts. After two years, the difference will have accumulated to 22: the start of lunar months fall 11 days earlier in the solar calendar each year. These days in excess of the solar year over the lunar year are called epacts (Greek: epakta hēmerai). It is necessary to add them to the day of the solar year to obtain the correct day in the lunar year. Whenever the epact reaches or exceeds 30, an extra (so-called embolismic or intercalary) month has to be inserted into the lunar calendar; then 30 has to be subtracted from the epact.

Note that leap days are not counted in the schematic lunar calendar: they are a device to match the calendar year to the tropical year, and can be ignored when dealing with the relation between years and lunations. The nineteen-year cycle (Metonic cycle) assumes that 19 tropical years are as long as 235 synodic months. So after 19 years the lunations should fall the same way in the solar years, and the epacts should repeat. However, $19 \times 11 = 209 \equiv 29 \pmod{30}$, not $0 \pmod{30}$; that is, 209 divided by 30 leaves a remainder of 29 instead of being an even multiple of 30. So after 19 years, the epact must be corrected by +1 day in order for the cycle to repeat. This is the so-called saltus lunae. The extra 209 days fill seven embolismic months, for a total of $19 \times 12 + 7 = 235$ lunations. The sequence number of the year in the 19-year cycle is called the "Golden Number", and is given by the formula

$$GN = Y \bmod 19 + 1$$

That is, the remainder of the year number Y in the Christian era when divided by 19, plus one.

Or in other words, you determine which of the 19 potential patterns of interaction between solar and lunar year a given year falls into by plugging some numbers into a formula and solving it.

(9)

The actual calculation of the date of Easter Sunday is done through the use of one of several algorithms. One such was first presented by the mathematician Karl Freidrich Gauss (10). Essentially, for any given Paschal full moon (being the first ecclesiastical full moon following the Vernal Equinox), there are seven potential dates that may be Easter, because Easter always falls on a Sunday.

So like this:

(All numbers are floored to the integer directly below them -- for instance, 2.2 becomes 2, as does 2.7)

(% means mod, which is the remainder of two numbers -- for instance, 11 mod 3 (11%3) is the remainder when 11 is divided by 3.
11%3 = 2)

Easter 2009, as calculated by the Meeus/Jones/Butcher Gregorian algorithm...

a = Year%19
2009%19 = 14

b = Year/100
2009/100 = 20

c = Year%100
2009%100 = 9

d = b/4
20/4 = 5

e = b%4
20%4 = 0

f = (b+8)/25
(20+8) = 28/25 = 1

g = (b-f+1)/3
(20-1+1)/3 = 20/3 = 6

$$h = (19*a+b-d-g+15)\%30$$

$$(19*14+20-5-6+15)\%30 = (266+20-5-6+15)\%30 = 290\%30 = 20$$

$$i = c/4$$

$$9/4 = 2$$

$$k = c\%4$$

$$9\%4 = 1$$

$$L = (32+2*e+2*i-h-k)\%7$$

$$(32+2*0+2*2-20-1)\%7 = (32+0+4-20-1)\%7 = 15\%7 = 1$$

$$m = (a + 11*h + 22*L)/451$$

$$(14+11*20+22*1)/451 = (14+ 220 +22)/451 = 256/451 = 0$$

$$\text{month} = (h+L-7*m+114)/31$$

$$(20+1-7*0+114)/31 = (20+1-0+114)/31 = 135/31 = 4 \text{ (April)}$$

$$\text{day} = ((h+L-7*m+114)\%31)+1$$

$$((20+1-7*0+114)\%31)+1 = ((20+1-0+114)\%31)+1 = (135\%31)+1 = 11+1 + 12$$

April 12

Easter 2010 as calculated by the Carl Friedrich Gauss method

First, find the values of M and N. For the Gregorian calendar, they are as follows:

| Years | M | N |
|-----------|----|---|
| 1583-1699 | 22 | 2 |
| 1700-1799 | 23 | 3 |
| 1800-1899 | 23 | 4 |
| 1900-2099 | 24 | 5 |
| 2100-2199 | 24 | 6 |
| 2200-2299 | 25 | 0 |

We're in 2010, so M = 24 and N = 5.

$$a = \text{year}\%19$$

$$2010\%19 = 15$$

$$b = \text{year}\%4$$

$$2010\%4 = 2$$

$$c = \text{year} \% 7$$

$$2010 \% 7 = 1$$

$$d = (19a + M) \% 30$$

$$(19 * 15 + 24) \% 30 = (285 + 24) \% 30 = 309 \% 30 = 9$$

$$e = (2b + 4c + 6d + N) \% 7$$

$$(2 * 2 + 4 * 1 + 6 * 9 + 5) \% 7 = (4 + 4 + 54 + 5) \% 7 = 67 \% 7 = 4$$

If $(d+e) < 10$ then Easter is the $(d+e+22)$ th of March. Otherwise, Easter is the $(d+e-9)$ th of April.

There are two notable exceptions. If the algorithm returns April 26, then Easter is on April 19.

If the algorithm returns April 25 AND $d=28$ AND $e=6$ AND $a < 10$, then Easter is on April 18.

$$(9+4) = 13$$

$$13 > 10$$

$$(9+4-9) = 4$$

April 4

So, in plain terms, depending on what day of the week the Paschal full moon falls on, Easter may be any of the seven days following (11).

And now, if you peek out your window and see that fat silver thing hanging up there resembling a skull or a sideways rabbit, you may note that today is: a real full moon, the Paschal full moon, the Vernal Equinox, *and* Good Friday.

(1) for ~26.3 months(2).

(2) intermittently and noncontiguous

(3) statistical approximation

(4) That's Latin for "*computation*".

(5) This entire process represents a compromise almost two millennia old, by the way (https://www.livejournal.com/away?to=http%3A//en.wikipedia.org/wiki/Easter_controversy)..

(6) the leftover time, or variance: the 365-day solar year is approximately 11 days longer than the 354-day lunar year, so one must occasionally insert an intercalary lunar month--like a leap month--if one is using both and cares to keep them somewhat synchronous. In other words, the epact is the leftover days between a lunar and solar year, for those of you playing the home game. 29 days in three cycles. *Or not quite* a lunar month. So every 3 years the lunar year gets a leap month, and every 19 years, it gets a leap day.

(7) named for Meton of Athens

(8) 19 tropical years = 235 synodic months, approximately speaking. There is no harmonic lock between the Earth, Sun, and Moon. The music of the spheres is slightly off-key.

(9) Incidentally, this is also what causes equinox jitter, or the reason why the equinoxes do not always fall on the same calendar day.

(10) 1777-1855, of deGaussing fame. Child prodigy. Among other things. Look him up.

(11) The pattern determining the date upon which Easter will fall follows a five million, seven hundred thousand (5,700,000) year cycle. Easter can fall anywhere from March 22nd to April 25th. We are such *complicating* mammals.

TAGS: math



Three things!

1) Okay, O., She Wants Revenge = yes. It's like the Eighties rose up from the grave and came looking


Experimental Whole Wheat Green Chile Robot Bread #1

Yes, baking with your hands is more fun. And the results have a better texture, and taste better.

[locked] Dream Journal

All right, unconscious mind. We're coming to an accommodation. If the dreams are you cleaning

40 comments

 [pnkrokhockeymom](#)

[March 22 2008, 03:02:30 UTC](#) [COLLAPSE](#)

While I was packing up my bags at the local fancy market the other day (some sort of fancy chicken breast halves for company), the customer behind me in line asked the cashier if she knew why Easter's always on a different Sunday.

I explained, roughly, what you've got above, but *without* the equations. Because an awful lot of people end up in law school instead of grad school for one simple reason: there's no math on the LSAT.

(Catholic school, for nearly a decade, until I convinced my parents that Catholic high school was really just overkill and over-populated with very rebellious young men who might be bad influences.)

g



 [cvillette](#)

[March 22 2008, 03:55:43 UTC](#) [COLLAPSE](#)

Brain the size of a planet--

g



 [pnkrokhockeymom](#)

[March 22 2008, 12:27:37 UTC](#) [COLLAPSE](#)

me big word brain...recovering math phobic...

I never understood the math of this...I knew it was math. (I think when I told the cashier and my fellow shopper the deal, in the spot of the explanation where your math is? I said, "and there's math, too.").

I believe I like tipsy math posts almost as much as cooking posts.



 [cvillette](#)

[March 22 2008, 12:33:52 UTC](#) [COLLAPSE](#)

More math is done while tipsy than you might anticipate....



 [pnkrokhockeymom](#)

[March 22 2008, 12:37:29 UTC](#) [COLLAPSE](#)

Actually, I find that pretty unsurprising. My job is rife with the need to explicate (and in some cases decimate) crazy economic market theories...the best time to do a first read on some hired gun's

"expert witness report" is after a glass of wine.

 [uffer](#)

[March 22 2008, 08:49:22 UTC](#) [COLLAPSE](#)

I usually settle for 'it's based on a lunar calendar'; the people I work with are generally not interested in detail. Once they're aware that there is an explanation and that I think it makes at least a sort of sense and therefore they will have to stop whining about it, they kinda switch off if I try to go into any more detail*. I hadn't known the actual math, though, so thank you for that, Coyote. Not that I will remember the details, but it's nice to have seen it, anyway.

* - This is why I'm so taken aback on the rare occasions somebody actually /is/ interested in whatever obscure Thing I have just mentioned in passing.

 [beatriceeagle](#)

[March 22 2008, 03:19:17 UTC](#) [COLLAPSE](#)

Math, mythology, *and* political intrigue. What more could a geek ask for?

(Well, technology of some sort. But I'm sure there's a computer program for it all out there somewhere.)



 [cvillette](#)

[March 22 2008, 03:52:22 UTC](#) [COLLAPSE](#)


I behaved myself, and didn't even get into the politics!



 [beatriceeagle](#)

[March 22 2008, 03:58:47 UTC](#) [COLLAPSE](#)

Oh, you behaved yourself better than I would have. I don't have much impulse control when it comes to geeky stories.

 [mearn4d10](#)

[March 22 2008, 03:20:50 UTC](#) [COLLAPSE](#)

...Jesus Mathematician CHRIST.

I think the last Catholic braincell just friend. Ow.



 [cvillette](#)

[March 22 2008, 03:52:39 UTC](#) [COLLAPSE](#)

Math is fun!



[I think it's more than 10...](#)



 [malthus25](#)

[March 22 2008, 03:54:19 UTC](#) [COLLAPSE](#)


If only because of all the Jewish mathematicians who also drive themselves crazy with the Metonic calendar (the Jewish version is somewhat more complicated, with several separate possible intercalary days, to avoid ~3 holidays from falling on the wrong day of the week).

And no, I didn't have to write a program to convert from Gregorian to Jewish in high school to avoid a failing grade, why do you ask? :-)


P.S. I friended you; I like your cooking posts (although I really only cook ~5 dishes myself). I hope you don't mind.

 **Re: I think it's more than 10...**
 **cvillette**
March 22 2008, 04:05:05 UTC COLLAPSE

Not at all, and nice to meet you!

 **desultorie**
March 22 2008, 04:15:59 UTC COLLAPSE

I still don't understand how the Catholics can celebrate the crucifixion & resurrection before Passover. We have a full five weeks until our Pascha.


 **cvillette**
March 22 2008, 04:57:04 UTC COLLAPSE

The Pope takes a a golden-headed ivory dart from a reliquary and throws it at a calendar supported by two cardinals.


 Deleted comment

 **cvillette**
March 22 2008, 11:23:50 UTC COLLAPSE

Orthodox churches still use the Julian calendar. I have no personal experience, but the internet tell me they use an algorithm for determining Easter too, and theirs includes a rule about Passover.

 **desultorie**
March 22 2008, 11:55:42 UTC COLLAPSE

The rule about Passover is included because Jesus can't die before the Last Supper.

 **sylvan_eve**
March 26 2008, 01:25:22 UTC COLLAPSE

my hubby is giggling at my cluelessness.....


after i remarked that it makes sense that Jesus cannot die before the Last Supper (I had no idea it

was a Passover meal) he commented:

"um.... that's the whole reason the Eucharist is made of unleavened bread..."

yeah. never made the connection



 [trolldatz](#)

[March 22 2008, 05:21:08 UTC](#) [COLLAPSE](#)

And the best part of all?

Ladies and gentlemen, he did that while not exactly what most of us would refer to as dead sober.



 [cvillette](#)


[March 22 2008, 05:47:43 UTC](#) [COLLAPSE](#)

Sober as a murch chouse.

Er. Sober as a bishop.

-.0



 [trolldatz](#)

[March 22 2008, 05:59:00 UTC](#) [COLLAPSE](#)

mrfles bibulously

The bishop is only sober because the murch chice chewed their way into the liquor cabinet and consumed all the Bushmills.



 [Ometotchtli](#)

[March 22 2008, 05:59:46 UTC](#) [COLLAPSE](#)

Chewing is thirsty work.



 [cvillette](#)

[March 22 2008, 06:08:09 UTC](#) [COLLAPSE](#)

chews faster

Hey, shouldn't you be annoying the notaboy?



 [cvillette](#)

[March 22 2008, 06:01:35 UTC](#) [COLLAPSE](#)

Well, it was St. Patrick's Day (observed). It was a moral imperative.

I have the best friends.



 [inauroliillium](#)

March 22 2008, 07:28:54 UTC

COLLAPSE

Oh, good. I'm not the only one.



[rickybuchanan](#)

March 22 2008, 14:19:05 UTC

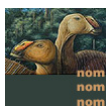
COLLAPSE

reads post *reads TrollComment* OMG.

gets down on knees Chaz, dearest, will you marry me?

Pretty pretty please with sugar on top and a free D10 drip inserted whenever you need it?

r



 [cvillette](#)

March 22 2008, 14:31:22 UTC

COLLAPSE

I'd be very tempted. Except the commute might be kind of a pain, don't you think?



[rickybuchanan](#)

March 22 2008, 23:52:56 UTC

COLLAPSE

For you, I'd even move house. You *do* have good health insurance, right?

And pain doesn't scare me ... well, except the kind your girlfriend is liable to inflict upon me if she reads this!



 [cvillette](#)

March 23 2008, 00:00:11 UTC

COLLAPSE

That is one thing about my job. The health coverage does not suck.

And she'd be more likely to hurt ME. When she DOES read this....



[rickybuchanan](#)

March 23 2008, 01:06:41 UTC


COLLAPSE

See, I could *use* your incredible health coverage and maybe get some Proper Treatment for these mitochondria which don't love me. But I won't because I would cry if Tasha hurt you ... :(

Please dear Tasha, I take it all back. No hurting Chaz OK?

hides under sofa




 [inaurolillium](#)

[March 22 2008, 06:40:04 UTC](#) [COLLAPSE](#)

I am absolutely fascinated by this, or would be, if I didn't currently have the attention span of a gnat, due to being a) TRIUMPHANT and b) drunk.

For, you see, I has grajiated.




 [inaurolillium](#)

[March 22 2008, 06:40:35 UTC](#) [COLLAPSE](#)

PS, I will come back and be fascinated when I am neither drunk nor hung over nor exceptionally tired.



 [sprrwhwk](#)

[March 22 2008, 11:00:28 UTC](#) [COLLAPSE](#)

For, you see, I has grajiated.

Congratulations! (Soon, SOON, I too shall be free. It would have been this spring, but the excrement was not well-collected in an expeditious manner, and so I'll have to suffer through until next spring, but there IS a light at the end of the tunnel. Even if it's receding a bit, it's still getting proportionately closer. Right? RIGHT? I've been in school for seventeen years of my life. What's another year in the grand scheme of things? It could be worse, I could be going to grad school next. *shudder*)

At any rate, many happy returns, wherever you go from here! :-)



 [inaurolillium](#)

[March 22 2008, 17:57:56 UTC](#) [COLLAPSE](#)

You *will* get out of there. Really. They made me take one more quarter, too, after they'd told me I could graduate in December.

Thanks!



 [cvillette](#)

[March 22 2008, 11:24:36 UTC](#) [COLLAPSE](#)

Woooo!

Did they make you wear a cake shaped like a mortar board?



 [inaurolillium](#)

[March 22 2008, 18:03:18 UTC](#) [COLLAPSE](#)

Alas, no. If they had, I would have had something with which to sustain myself during the incredibly bad speeches. ("Award-winning scone"? Really? And the number of times the culinary program was ignored entirely!) We did not, in fact, get to wear any sort of head-covering. Culinaricians apparently graduate in chef's jackets, extra-fancy ones with assorted logos embroidered on, and those stupid plastic studs instead of actual buttons. But toques are to be worn only in the kitchen, so we got no hats, nor tassels either.



[cjtremlett](#)

[March 22 2008, 13:41:20 UTC](#)

[COLLAPSE](#)

Wow. Being pagan, I was aware that Easter and Oestara were much closer than usual this year, and was aware of the full moon as well. I didn't realize all of that, though!

So that, ladies and gentlemen and others, is a geekgasm.



[cvillette](#)

[March 22 2008, 14:39:16 UTC](#)

[COLLAPSE](#)

It's like they intentionally set out to make it as needlessly complicated as humanly possible.

It's like Three-cornered Pitney. With religion.



[uffer](#)

[March 22 2008, 17:32:41 UTC](#)

[COLLAPSE](#)

Well, can't have people working it out for themselves, can they? Then people would start wondering why they needed the whole edifice that is Organised Religion, and then you get Heresy and the necessity for crusades and the like, which are Expensive.

Ask the Albigensians.



[tsiankiio](#)

[March 22 2008, 16:20:29 UTC](#)

[COLLAPSE](#)

Plus, it was Purim in some places too (Purim lasts longer in ancient walled cities).

Three things!

1) Okay, O., She Wants Revenge = yes. It's like the Eighties rose up from the grave and came looking

Experimental Whole Wheat Green Chile Robot Bread #1

Yes, baking with your hands is more fun. And the results have a better texture, and taste better.

[locked] Dream Journal

All right, unconscious mind. We're coming to an accommodation. If the dreams are you cleaning